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Application of ERTS and EREP Images to Geologic Investigations of the Basin and Range - Colorado Plateau Boundary in Northwestern and North Central Arizona

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Problems

We have received tapes of five scenes, two just before the report deadline. The first was not useable because of a cirrus layer which was no fault of the spacecraft. However the tapes from the remaining four scenes exhibit defects of varying degrees of severity. Scene 1014-17373 shows severe banding in band 4, an apparent low gain state in one of the detectors. On an unenhanced frame the banding is barely noticeable, but after computer processing and contrast stretching the banding is so prominent that it severely detracts from the rest of the picture. Any picture convolved with the green frame, such as a multi-spectral enhancement, exhibits the same problem. Tapes from frame 1014-17375 show a similar problem in band 7 as well as band 4. Tapes from frames 1032-17373 and 1032-17375 show more serious defects. Many lines show bit errors and much random noise. Banding is serious in several bands. The NDPF photographs seem to be quite clean, and it is difficult to believe that the spacecraft-ground link is responsible. It would appear that the noise was introduced in the recording of the computer compatible tapes. Because of the large delay in obtaining tapes, we hope these problems can be resolved soon. As of yet we have not received a tape of the Shivwits Plateau area, our third test site.

Accomplishments and Plans

Computer Image Processing

Because of the above-mentioned tape problems we devoted most of our efforts to developing a program named ERTS FIX which can partially restore the fidelity of the original scene before further analysis is attempted.

We were successful to a large extent in compensating for the apparent low gain state of one of the detectors. However random bit errors can only be accommodated by restoring the line with the average value of the two adjacent lines on a pixel by pixel basis. This method, while producing a smooth picture, is basically unacceptable because resolution is lost.

A comparison was made between the NDPF color reconstruction and the radiometric data in a small area around Clarkdale, Arizona in the Verde Valley. Good differentiation of geologic units is achieved in the color frames only in a restricted middle brightness

range. If the average brightness is high such as in the bright lacustrine deposits in Verde Valley, or low such as in the great Jerome Mine slag pile or the water of the Verde River, little or no differentiation is possible. The tapes contain a large amount of radiometric information which cannot be displayed on a single color print or transparency. For instance we can uniquely separate the Jerome Mine slag pile and the ox-bow lake, adjacent in the Verde River, which both appear black on the color composite.

In the next reporting period we will begin to apply filtering routines to enhance structure, geometric stretching routines to bring the bulk image to map projection and multispectral routines to classify the geologic units.

Shivwits Plateau

October was the wettest month ever recorded in the area, and November the coldest November on record, and also one of the wettest months. This combined to make our fall field campaign on the Shivwits rather ineffectual, and forced us to turn our attention to other efforts. These have consisted of (a) studying and making photogeologic maps of whatever ERTS images were available, and (b) reconnoitering on the ground the country immediately north of the Shivwits Plateau. This country, which is low in elevation and thus still accessible, has excellent exposures, and is very important in terms of structural patterns and possible ancient river courses.

Because the area is covered with material of generally high albedo, the ERTS negatives are too dense to obtain enlargements to 1:250,000 scale necessary for mapping. Shortly before the end of this reporting period, we received the first prints of the area. But study of the other photos is proving very profitable; we are learning what and how to map on photos of that scale; we are detecting and plotting extremely interesting structural patterns, some possibly not recognized previously, which will later be contrasted with structural patterns on the Plateau; we may have discovered several circular structures, one very large, of as yet unexplained origin; and we have found that ERTS photographs are very useful for studying and analyzing large-scale geomorphic features such as retreating scarps and possible ancient stream valleys. In all these activities, we have found, as expected, that the single most useful feature of the ERTS imagery is its ability to provide a relatively undistorted view of a large piece of terrain (i.e., a synoptic view).

The reconnaissance field studies have centered in the area of the St. George Basin, in SW Utah and directly north of the Shivwits Plateau. This area is important because the postulated ancient streams of pre-Colorado River age, for which we have found some evidence on the Shivwits, very probably continued through the St. George Basin area. Therefore we have attempted to find direct evidence in the form of channels and gravels, or indirect evidence in the form of areas that would have been topographically low at the time in question because of structural and lithologic characteristics. We have not found evidence of the first kind, nor is it likely that we ever will, but we have narrowed down to about two or three the areas where channels may have existed at the time of interest. No less important, we have had the opportunity to study in the field the structural transition from Plateau to Basin and Range in the area contiguous to that of the Shivwits Plateau.

The next two or three months will be devoted to analysis of the field data obtained to date, to literature studies, and to photogeologic analysis of ERTS and aircraft underflight photographs. We have experienced great difficulties with the procurement of appropriate satellite and aircraft images, and many of the images obtained have been of unusually poor quality. But now, finally, we seem to be on the way to obtaining what we need, and our orders for usable material should be filled any day.

Cataract Creek

Examination of the bulk prints of frame 1014-17373 shows many obvious lineaments from which structural interpretations can be made. Preliminary reconnaissance field mapping has been carried out over an area of approximately 175 square miles, and it is now apparent that obvious features on the 9-inch prints do not have obvious geologic interpretations and vice versa. The northern edge of the Mt. Floyd volcanic field has been mapped in detail. Reconnaissance of the area up to 10 miles north of the volcanic field has shown that faults in this area juxtapose different members of the Kaibab Formation with each other and with the Moenkopi Formation. The bulk prints do not show these relationships well. There are suggestions, particularly in band 5, of contrasting areas in the print which coincide vaguely with areas underlain by Moenkopi.

Many of the obvious lineaments are faults, but on the bulk prints, the distinction between fault, monoclinal and erosional scarps is impossible. The prints do not unambiguously show contacts between stratigraphic and more recent alluvial units with any degree of precision. Work in the next reporting period will concentrate on computer enhancement of the relevant frames for better structural visibility and better contrast among mappable units.

Mr. Mike Foley, listed as an associate investigator and a graduate student under E. M. Shoemaker, has decided to pursue a different Ph. D. thesis project. For this reason the office work on the Cataract Creek region will be confined to image processing until a replacement is found for Foley. Mr. Richard Squires, now completing his thesis work at CIT, has expressed an interest in our work and may join the project at a later date. Hopefully this will be possible by March 1, the approximate beginning of the field season.

Central Arizona

ERTS frame 1014-17375, bands 4-7, has been enlarged to ~ 1:200,000 scale. It is being analyzed for its structural and general geologic content for Area D and the surrounding region in northcentral Arizona. The area under study includes parts of the Colorado Plateau on the north, the bounding Mogollon Rim, and the bordering "Mountain Region" on the south, which in turn passes into Basin and Range structure.

Structural lineaments in Precambrian, Paleozoic and Cenozoic rocks are well displayed in the ERTS photograph. A number of lineaments can be related to faults and fault zones in Precambrian rocks mapped in six 15' quadrangles (1:48,000 and 1:62,500 scales) that lie west and south of the Verde Valley (central part of Area D). The quadrangles (Paulden, Clarkdale, Prescott, Mingus Mountain, Mount Union, and Mayer, lying between 34°15'N. and 35°N., and 112°W. and 112°30'W.) are serving as control for the structural analysis. In a number of cases apparent extensions of lineaments mapped in the Precambrian basement rocks can be seen in the ERTS photograph, which sheds new light on the character of the basement beneath a cover of Phanerozoic rocks.

The object of the structural mapping is to obtain information on the relative strengths and ages, and the inter-relationships of three well-developed regional fracture systems, which trend (1) northeast, (2) north, and (3) northwest. During the Precambrian, an older strongly developed northeast-trending fracture system appears to have been modified by a locally strongly developed north-trending system, and also by an apparently less strongly developed northwest-trending system. This pattern controlled structural adjustments which occurred much later, mainly during the evolution of the Colorado Plateau and Mountain Region during the Cenozoic, and the attendant development of the Colorado Plateau boundary. Middle and Late Tertiary volcanism has apparently been localized along certain of the major structural lineaments. For example, one part of the north- and northwest-trending east-Kaibab monocline near the Grand Canyon and Gray Mountain Arizona, about 100 km to the north and on the Colorado Plateau, changes strike abruptly to the southwest; along its extension there are several extrusive features which include Red Mountain, Sitgreaves Mountain, and Bill Williams Mountain. Mapping of the lineament systems in Precambrian and Phanerozoic rocks should provide regional information for better understanding the structural evolution of the Colorado Plateau margin in central Arizona.

During evolution of the Colorado Plateau margin in and near the Verde Valley, a series of basalt flows cascaded from the plateau area as well as erupted from source areas in and south of the Verde Valley. Curiously, these flows (flows of the Hickey Formation of the Mingus Mountain area, flows of the Verde Valley volcanic center in the southeastern Verde Valley, and flows that border the Verde Valley on the north) appear to be distinctly darker in ERTS bands 5, 6, and 7 (.6-1.1μ) than flows that cap most of the adjacent Colorado Plateau area to the north. The reason for this is not understood. Obvious structural and genetic boundaries between the flows of different contrast on the ERTS images are not apparent in the field.

Data Request Forms

Retrospective requests were made for tapes and other film products on October 2, 2 frames; November 2, 3 frames; November 21, 4 frames.

Other Information

Because of the lack of tapes for processing we have not fully manned the computer operation. As will be seen on the financial statement, sent under separate cover, we have been underspending to this time. As more data arrives, we will add the personnel needed to meet our objectives set forth in the Statement of Work.